

# Hyperspectral Remote Sensing of Atmosphere and Surface Properties

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**Abstract**— Atmospheric Infrared Sounder (AIRS), Infrared Atmospheric Sounding Interferometer (IASI), and Cross-track Infrared Sounder (CrIS) are all hyper-spectral satellite sensors with thousands of spectral channels. Top of atmospheric radiance spectra measured by these sensors contain high information content on atmospheric, cloud, and surface properties. Exploring high information content contained in these high spectral resolution spectra is a challenging task due to computation effort involved in modeling thousands of spectral channels. Usually, only very small fractions (4–10 percent) of the available channels are included in physical retrieval systems or numerical weather forecast (NWP) satellite data assimilations.

We will describe a method of simultaneously retrieving atmospheric temperature, moisture, cloud, and surface properties using all available spectral channels without sacrificing computational speed. The essence of the method is to convert channel radiance spectra into super-channels by an Empirical Orthogonal Function (EOF) transformation. Because the EOFs are orthogonal to each other, about 100 super-channels are adequate to capture the information content of the radiance spectra. A Principal Component-based Radiative Transfer Model (PCRTM) developed at NASA Langley Research Center is used to calculate both the super-channel magnitudes and derivatives with respect to atmospheric profiles and other properties. There is no need to perform EOF transformations to convert super channels back to spectral space at each iteration step for a one-dimensional variational retrieval or a NWP data assimilation system. The PCRTM forward model is also capable of calculating radiative contributions due to multiple-layer clouds. The multiple scattering effects of the clouds are efficiently parameterized. A physical retrieval algorithm then performs an inversion of atmospheric, cloud, and surface properties in super channel domain directly therefore both reducing the computational need and preserving the information content of the IASI measurements. The inversion algorithm is based on a non-linear Levenberg-Marquardt method with climatology covariance matrices and a *priori* information as constraints. One advantage of this approach is that it uses all information content from the hyper-spectral data so that the retrieval is less sensitive to instrument noise and eliminates the need for selecting a sub-set of the channels.